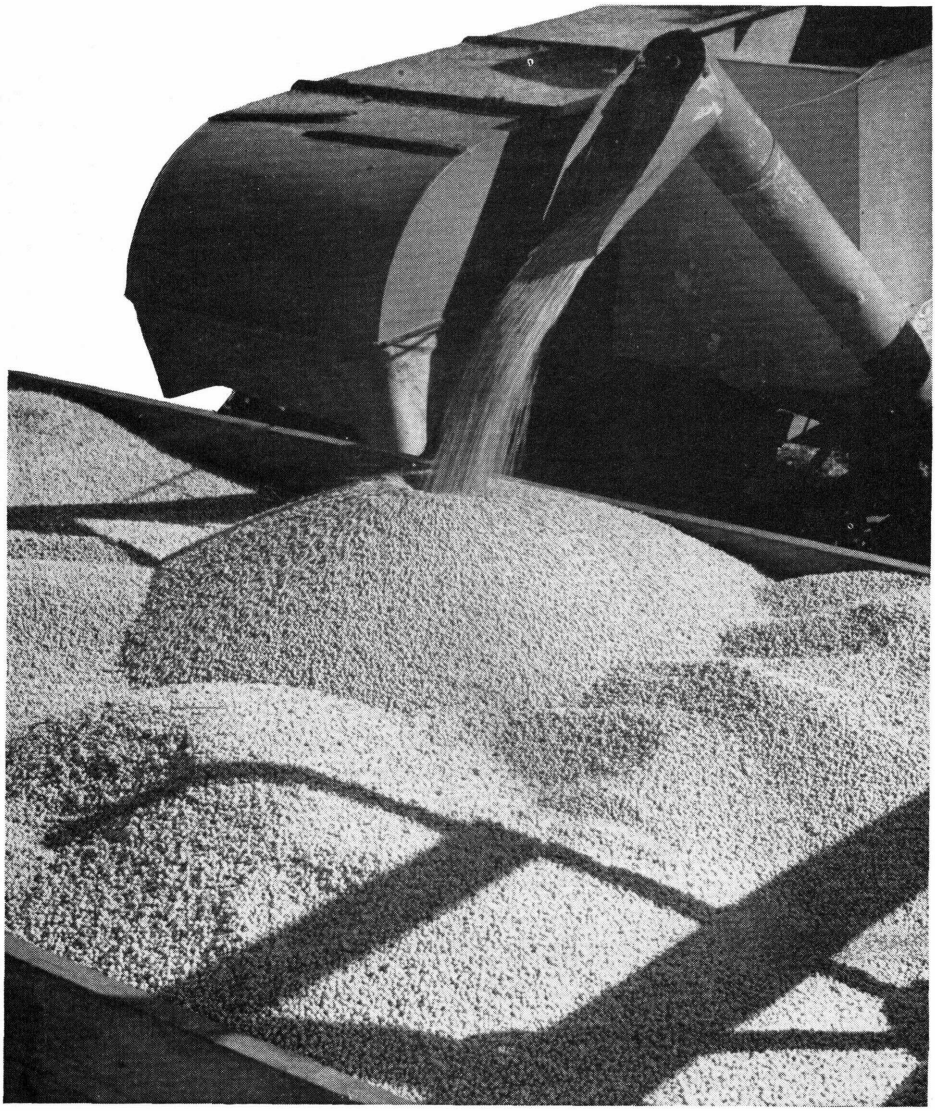
SOYBEANS

for Feed, Food, and Industrial Products



Farmers' Bulletin No. 2038

United States Department of Agriculture

THE EXTENSIVE utilization of the soybean for oil and meal, added to its use for forage and for human food, has resulted in a great increase in the acreage of the crop in recent years. Improved varieties for industrial processing and more efficient methods for growing and harvesting have helped in the expansion of production and in the improvement of the quality of the crop.

Soybean meal is manufactured into grits, flakes, and flour for human consumption. Oil removed from soybeans is used extensively in the preparation of shortenings, margarines, and salad oils and in the manufacture of paints, varnishes, and many similar products.

In feeding value the soybean compares favorably with other high-protein concentrates for livestock. Soybean hay has about the same feeding value as other legume hays. As a pasture crop the soybean is valuable for livestock of all kinds. It furnishes satisfactory pasturage in late summer and early fall, when perennial pasturage may be short. Much of the information on utilization by livestock is a review of the work of the State agricultural experiment stations.

Additional information on the soybean is given in Farmers' Bulletin 1520, Soybeans: Culture and Varieties; Farmers' Bulletin 1937, Soybean Diseases and Their Control; and Farmers' Bulletin 2024, Soybean Production for Hay and Beans.

This bulletin supersedes Farmers' Bulletin 1617, Soybean Utilization.

Washington, D. C. Issued February 1952

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. — Price 15 cents

SOYBEANS FOR FEED, FOOD, AND INDUSTRIAL PRODUCTS

By W. J. MORSE, formerly *principal agronomist*, and J. L. CARTTER, *senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

Contents

IMPORTANCE OF THE SOYBEAN AND ITS BYPRODUCTS

THE SOYBEAN, an annual summer legume, is grown in the United States principally for its seed, which is used in the production of oil and meal. Most of the meal is used for livestock feed, though its use in food and industrial products is increasing. The oil is used principally in shortenings, margarine, and salad oils, with a portion being used industrially as a drying oil.

The record increases in acreage and production of soybeans, which have advanced from a position of minor importance about 1929 to one of major importance today, show the present economic value and importance of the crop in the United States. It now ranks fifth in importance among the farm crops. At first the soybean was grown largely as a substitute crop when clover or some other crop failed; today it has a permanent place in the cropping system of many Great Plains farms.

Before 1935 the soybean largely was used in the United States for forage—preserved either as hay or silage, cut and fed green as soilage, grown as a green-manure crop or as a summer crop in orchards, and also pastured with hogs and sheep. Though the soybean is still used

extensively as a forage crop, the large increase in acreage since 1941 has been for the production of beans. In 1950 about 83 percent of the acreage was for beans, 9 percent for hay, and 8 percent for pasture and plowing under. Most of the soybean acreages used for hay, grazing, plowing under (green manure), and interplanting with other crops are in the Southern States.

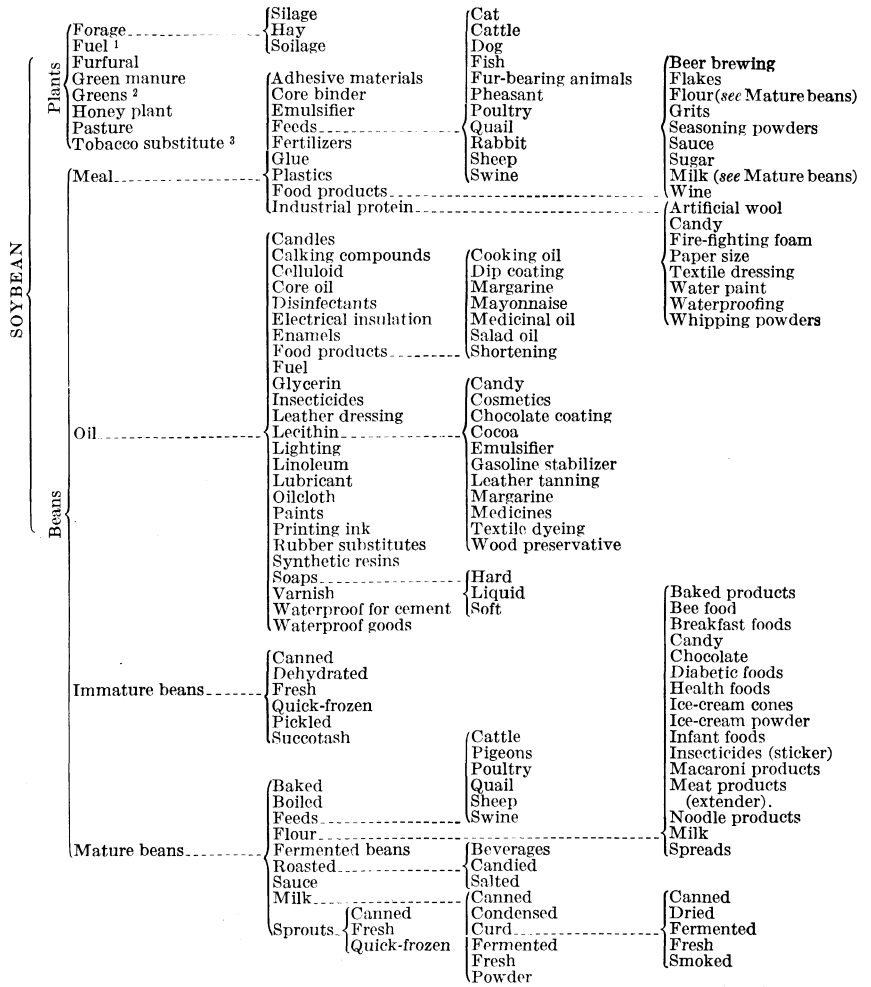
Unlike the seed of most other legumes, that of the soybean is rich in oil, which makes the crop an important source of vegetable oil and meal. Soybeans were not extensively processed for oil and meal in the United States until after 1929; it was not until 1935 that about one-half the domestic production was processed. Production and processing have increased at a phenomenal rate since 1939 (table 1). In 1949 more than 88 percent of the soybeans were processed, the remainder being used mainly for seed; before 1934 the largest proportion of the production went for seed to plant the next year's acreage.

TABLE 1.—*Production and utilization of soybeans in the United States, 1924–49*

Year	Production	Utilization				
		Seed (planting)	Feed	Oil and meal	Exports	Other uses
	1,000 bushels	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*
1924	4, 947	1, 900	1, 207	307	----------	1, 596
1929	9, 438	3, 762	1, 730	1, 666	----------	2, 298
1934	23, 157	10, 066	2, 036	9, 105	19	1, 643
1939	90, 141	15, 974	5, 365	56, 684	10, 979	1, 713
1944	191, 958	18, 885	3, 598	153, 402	5, 090	17, 402
1949	230, 897	19, 000	2, 933	195, 115	13, 137	955

The soybean is important as a source of highly nutritious foods and feeds and an extensive list of industrial products. These include the following:

Soybean Utilization



[1] Roots and coarse stems are used as fuel in China, Manchuria, and Korea.
[2] In many parts of China the plants, when 3 to 4 inches high, are used as greens.
[3] In Manchuria and Korea, the leaves are cured and smoked as tobacco.

Since 1924 more beans have been used for feed on farms where grown, but not in proportion to the increased production. In some areas the grinding and feeding of soybeans to dairy cattle have become fairly common.

Soybean foods now receiving the most attention are flour, flakes, grits, and oil. Various other food products made from the mature and immature beans are also on the market.

DIRECT USE OF SOYBEANS ON THE FARM

SOYBEAN HAY

In the past few years farmers in the North Central States have grown soybeans almost entirely for harvest as beans. In other areas, however, soybeans are used for forage, pasture, and green manure.

Soybean hay can be fed profitably to all kinds of livestock (fig. 1). As a source of protein produced on the farm to balance feeds for growing stock or for milk and butter production, soybean hay reduces the quantity of high-priced concentrates that it is necessary to buy. Feeding soybean hay alone is not advisable, as digestive troubles may result. The chief objection to the soybean for hay is that it has rather coarse, woody stems. This objection may be overcome to some

FIGURE 1.—A field of soybeans for hay. The crop is easy to produce and can be fed profitably to all kinds of livestock.

extent by using heavier rates of seeding, growing a good forage variety, and harvesting at the proper time. Chopping and grinding the hay reduce waste in feeding, though the refused portion is mostly coarse stems low in protein.

The principal value of soybean hay lies in its high content of digestible protein. Soybean hay compares favorably with other important hay crops in its content of digestible nutrients (table 2). Artificially dried hay is more nutritious than field-cured hay, especially if the latter is weathered in curing.

TABLE 2.—*Average composition and digestible nutrients of soybean hay and other important hays* [1]

Hay	Moisture	Ash	Protein	Carbohydrates		Fat	Digestible protein	Total digestible nutrients
				Fiber	Nitrogen-free extract			
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Soybean	9. 2	7. 3	14. 8	28. 4	37. 0	3. 3	11. 1	50. 6
Cowpea	9. 6	11. 3	18. 6	23. 3	34. 6	2. 6	12. 6	49. 4
Alfalfa	9. 6	8. 3	14. 7	29. 0	36. 4	2. 0	10. 6	50. 3
Red clover	11. 8	6. 4	11. 8	27. 3	40. 1	2. 6	7. 0	51. 9
Lespedeza, annual	10. 9	5. 4	12. 8	26. 2	42. 4	2. 3	9. 2	52. 2
Timothy	11. 3	5. 0	6. 2	30. 1	45. 0	2. 4	2. 9	46. 9

[1] Data obtained from MORRISON, F. B., FEEDS AND FEEDING. Ed. 20. 1050 pp., illus. Chicago. 1945.

Hay for Dairy Cattle

Soybean hay is satisfactory for dairy cattle. If the hay is cut before it becomes coarse it is the equal of alfalfa or red clover hay for the production of milk and butterfat and for maintenance of body weight of dairy cows. Soybean hay cut when the pods are completely formed, the beans well formed, and the lower leaves turning yellow is superior to hay cut in earlier stages of maturity for both milk and fat production. The cows may refuse about 5 percent of the hay, but the refused part consists of coarse stems, which are about 50 percent fiber and 3 to 5 percent protein, most of the protein being in a form not available to the animal.

When late-cut soybean hay containing seed forms the principal or only roughage, it is possible to feed too much to dairy cattle.

Feeding trials have shown that soybean hay fed as the only roughage has no detectable effect on the flavor of milk or cream. This was true of very moldy soybean hay, as well as of hay of excellent quality.

Hay for Beef Cattle

In feeding experiments with beef cattle, several State agricultural experiment stations compared gains made on soybeans and other legume hays. Most results show soybean hay to be equal to clover

and alfalfa hay in making gains and in economy of feeding when fattening steers. Soybean hay gives excellent results when fed with corn silage.

Hay for Horses and Mules

Practical experience, supplemented by feeding trials, shows that rations of soybean hay and corn or soybean hay, corn, and oats are satisfactory for work horses. Soybean hay is an excellent roughage for fattening mules. Horses and mules develop exceptionally smooth coats when fed soybean hay. No ill effects have been reported from the feeding of this hay, and the animals receiving it are said to endure heat well. Experiments show that soybean hay, when properly supplemented, is a satisfactory roughage for growing draft fillies; it is equal to alfalfa for the purpose. Soybean hay is superior to Johnson grass hay when fed with ear corn to mules.

Soybean hay appears to be fully as valuable as clover and alfalfa on the basis of digestible nutrients. For horses and mules, however, it should be well cured and should make up not more than half of the roughage. There is more waste with soybean hay than with alfalfa and clover because the woody stalks of the soybean plant are generally refused.

Hay for Sheep

Sheep consume relatively large quantities of roughage in comparison with grain. Feeding trials by various experiment stations and observations by many farmers indicate the suitability of soybean hay for all classes of sheep.

Soybean hay fed to breeding ewes has given results equal to those obtained with alfalfa. Lambs from an experimental lot of ewes fed only soybean hay until after lambing were equal in size and vigor at birth to lambs from ewes fed only alfalfa hay. Ewes from the two lots showed no noticeable difference in weight, vigor, health, or milking qualities.

Soybean hay is a good roughage for fattening lambs, giving as large gains as alfalfa or clover hay when fed in a good ration, especially when the soybean hay is ground. Only the finest leafy soybean hay has proved suitable for young lambs.

Hay for Swine

The feeding of soybean hay to hogs is practiced in some areas. The crop is cut when the beans are fairly well matured and then stacked for feeding in winter. Feeding trials show that soybean hay as a supplement to corn and tankage for fattening hogs produces faster and more economical gains than corn and tankage alone. Experiments indicate that soybean hay, corn, and tankage make a satisfactory ration for wintering brood sows. Gilts on this ration have farrowed especially good litters compared to gilts on a ration of corn and tankage alone.

Hay for Poultry

Practical experience and feeding tests show that soybean hay, well cured without excess bleaching, makes an excellent winter feed for poultry. In some instances soybeans are cut when the pods begin

to form and are carefully cured to prevent loss of leaves. The general practice, however, is to cut soybeans for hay when the seed is one-half to three-fourths developed. It is most easily fed in racks or baskets hanging on the walls of the house or from the ceiling. Studies on the possibility of substituting ground soybean hay for alfalfa meal in laying rations show no significant difference in egg production, rate of mortality, egg hatchability, and weight of eggs laid by birds receiving alfalfa-leaf meal from those receiving soybean-hay meal, when used to supplement rations containing either yellow or white corn meal. Soybean-leaf meal prepared from artificially dried hay is usually leafier and more nutritious than that prepared from field-cured hay.

SOYBEANS FOR PASTURAGE

The soybean can be utilized to advantage as pasturage for livestock of all kinds. Pasturage is especially desirable when harvesting is hindered by weather conditions, lack of labor, or other causes, or when the crop is grown for soil improvement. Soybeans furnish a satisfactory pasturage in late summer and early fall when perennial pasturage may be short. Soybeans grow well with corn, and the two crops may be pastured down in the same manner as corn alone. The soybeans may be planted in alternate rows or mixed and drilled in the row with corn. Soybeans are a valuable part of annual pastures in combination with such crops as Sudan grass, sorghums, and millet. If a longer grazing period is desirable, varieties of soybeans differing in maturity may be sown or the same variety may be sown at different dates. Defoliation studies show that soybeans may be grazed until most of the leaves are removed, allowed to grow again for about 30 days, and then regrazed.

Hogging Down Soybeans

Soybeans make excellent supplementary hog pastures and are one of the best forage crops for general use in fattening hogs, especially in the Southern States. Because the crop is a legume, many farmers consider the increase of soil fertility that follows its grazing to be equivalent to the cost of growing the soybeans. Hogs turned on soybeans not yet mature will eat the leaves, the pods, and some of the stems. As a rule, it is more profitable to allow the beans to ripen before the crop is grazed.

Soybeans alone for pasture have given unsatisfactory gains with hogs. However, studies show that hogs on mature soybeans and corn are more thrifty and make faster and more economical gains than hogs in dry-lot on corn and tankage.

Cooperative research on hogging down soybeans and its effect on the firmness of pork shows that only under specific conditions will mature soybeans, hogged down, produce firm carcasses. Detailed information on this problem may be obtained from the Bureau of Animal Industry, United States Department of Agriculture, Washington 25, D. C.

Sheep on Soybean Pasture

Pasturing sheep on soybeans and corn is practiced throughout the Corn Belt. This combination furnishes feed not only for lambs being

965338°—52——2

prepared for market but also for breeding ewes. Soybeans make one of the best temporary pasture crops, especially on the less productive soils. The crop can be pastured from July until the first frost. It is usually desirable to allow 5 or 6 weeks between seeding and grazing. Sheep will eat weeds, soybeans, and corn leaves before touching much of the ear corn.

Beef and Dairy Cattle on Soybean Pasture

When grown alone, soybeans do not make as satisfactory pasturage for beef and dairy cattle as red clover, alfalfa, or sweetclover. Grazing materially reduces growth, and trampling causes a large waste of feed and damages the growing plant. A mixture of Sudan grass and soybeans for midsummer pastures has become popular among dairy farmers. In general, the seed may be planted the latter half of May; by the middle of July the plants usually are high enough to allow grazing to begin. While bluegrass pastures may cease growth in dry seasons, the Sudan grass-soybean combination withstands hot, dry weather exceptionally well.

Poultry on Soybean Pasture

Practical experience and research show soybeans to be a good summer pasture for poultry, especially growing chicks. Poultrymen find that soybeans planted in hills with corn on poultry ranges furnish excellent green feed, and the drying cornstalks provide protection against the cold winds of early fall. Soybeans supply succulent green feed continuously through late summer and early fall, and, because of their luxuriant growth, provide shade for the growing chickens.

Soybeans furnish excellent pasture for turkeys in summer and fall, especially in regions where clover and alfalfa are not grown. Where clover and alfalfa are grown, seeding failures of these crops may necessitate a substitute, such as soybeans, and, in addition, turkeys often kill out stands of alfalfa and clover. The soybean is an annual crop and can be planted the same season that turkeys are raised. Turkeys walk between the rows and graze from both sides, eating the leaves and later the beans. They consume less prepared feed when they have such pasturage.

SOYBEANS FOR SOILAGE

The soybean has an important place among soiling crops. Because of its high protein content it may be fed to good advantage with crops that are low in protein, such as corn, Sudan grass, and millet. The palatability of the soybean at all stages of development and the ease of handling make it a valuable crop for soilage. The range in maturity of different varieties or the maturity resulting from planting the same variety at different dates make it possible to have a succession of green forage throughout the summer and fall. Once established, the soybean grows well during periods of drought, often succeeding where other crops fail.

Experiments show that milk cows fed green soybean forage produce good yields of high-quality milk and butterfat. Freshly cut soybeans can be used to good advantage as a green feed to supplement poultry rations. The soybean supplies vitamin A, bulk, and succulence, taking the place of other common green feeds, such as alfalfa, sprouted

oats, or grass range, if these are not available. Table 3 shows the composition and digestible nutrients of the green forage of soybeans and other forage crops.

TABLE 3.—*Composition and digestible nutrients of green forage of soybeans and other crops* [1]

Crop	Moisture	Protein	Fat	Fiber	Nitrogen-free extract	Ash	Digestible protein	Total digestible nutrients
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Soybean	75. 6	4. 2	1. 1	6. 7	10. 1	2. 3	3. 2	15. 1
Cowpea	83. 7	3. 0	. 5	3. 8	7. 0	2. 0	2. 3	10. 9
Alfalfa	74. 6	4. 6	1. 0	7. 0	10. 4	2. 4	3. 4	14. 7
Kudzu	69. 4	5. 5	1. 0	8. 3	13. 6	2. 2	4. 2	19. 4
Lespedeza, annual	63. 4	6. 7	1. 0	10. 7	14. 7	3. 5	5. 0	20. 9
Red clover	75. 0	4. 0	. 9	6. 8	11. 2	2. 1	2. 6	15. 4
Velvetbean	82. 1	3. 5	. 7	5. 1	6. 6	2. 0	2. 6	12. 3
Corn fodder, dent, mature	76. 0	2. 0	. 6	5. 6	14. 5	1. 3	1. 2	16. 3

[1] Data obtained from MORRISON, F. B., FEEDS AND FEEDING. Ed. 20. 1050 pp., illus. Chicago. 1945.

SOYBEANS FOR SILAGE

In general, soybeans are not recommended alone as silage; like other legumes, ensiled alone they usually produce a rather bitter forage with a strong, disagreeable odor. Recent experiments indicate that a high-protein crop, if wilted to a proper moisture content—60 to 65 percent—and tightly packed, may produce a satisfactory silage. The addition of corn meal will give a well-preserved and palatable silage, as valuable for feeding as corn silage.

Corn alone is an unbalanced ration; it should be supplemented with feeds richer in protein. The soybean is an important supplement to corn for silage (fig. 2), about 2 or 3 parts corn to 1 part soybeans making a well-balanced silage that keeps well, is readily eaten by stock, and produces no bad effects in the quality of milk and its products. Some feeding experiments with dairy cows indicate little difference in value between corn-soybean silage and corn silage alone if sufficient protein concentrate is fed. Corn-soybean silage is popular, however, and a few recent experiments show that it is superior to corn silage.

SOYBEANS FOR SOIL IMPROVEMENT

The value of a crop of soybeans, as of other legumes used for soil improvement, depends on the inoculation of the plants, how much of the crop is returned to the soil, and the effect of the roots on the mechanical condition of the soil. Leguminous plants, through the aid of the root-tubercle organisms, are able to add to the available nitrogen of the soil and are extensively used in restoring soils deficient in nitrogen. Soybean plants with an abundance of nodules obtain about two-thirds of their nitrogen from the air and the rest from the soil.

If the soil is abundantly supplied with nitrates, the soybean obtains more of its nitrogen from the soil than from the air.

The soybean cannot be expected to be effective in adding to the fertility of the soil if the entire crop is removed and none returned in the form of straw, green manure, or animal manure. The average weight of soybean roots and stubble is about 10 percent of the hay crop removed. The nitrogen left in the soil in the roots and stubble averages 6 pounds an acre and that removed in the hay about 128 pounds an acre. This indicates that little nitrogen is left in the soil through the roots and stubble, but, when the soybean is well inoculated and har-

FIGURE 2.—The soybean forms a valuable supplement to corn for silage.

vested for beans and the straw left on the ground, there is a net gain of about 16 pounds per acre in the nitrogen content of the soil over the amount of nitrogen used by the plants to reach maturity. Soybeans rank about average among crops from the standpoint of removing mineral nutrients if the straw is left on the ground. A 25-bushel crop of soybeans will remove from the soil about the same amount of phosphorus as a 60-bushel corn crop and about twice as much potassium, but only about half as much potassium as a 2-ton crop of clover.

Soybeans grown alone are too valuable to plow under as green manure for soil improvement except under certain conditions, even though they have a highly favorable effect on yields of crops that follow. In some areas, if they follow wheat or oats they may make sufficient growth to add organic matter to the soil for winter wheat or other fall-sown crops. In Louisiana, soybeans are grown extensively for green manure in rotation with sugarcane.

For best results as a green manure, soybeans should not be allowed to become too mature before being turned under. Immature vines decay more rapidly and less soil moisture is consumed if the crop is turned under early. When the plant has reached the blossoming stage, most of the nitrogen has been gathered and the soybean plant decays rapidly in the soil. Tests at the United States Sugar Plant Station in Louisiana indicated the highest nitrogen content and approximately the highest acre yield of green and dry matter were obtained when the plants were in full bloom.

In oriental countries, the soybean is used intensively as a green-manure crop in rice paddies and young orchards.

SOYBEANS FOR LIVESTOCK FEED

The value of soybeans as a high protein feed for livestock is indicated by extensive feeding trials and practical experience. Soybeans can be used as a protein supplement to replace, at least partially, the expensive commercial protein concentrates necessary for stock feeding and milk production. Because most grains commonly used in stock feeding are deficient in protein and soybeans contain more protein than these grains, growing soybeans enables the farmer to produce at moderate cost part of his high-protein feeds.

The soybean is the cheapest and most efficient source of vegetable protein available to the farmer. It contains from 30 to 45 percent protein, which compares favorably with the protein content of other concentrated feeds. Soybean protein is superior to other vegetable proteins in common use because its amino acid content comes closer to that essential for the biological efficiency of a feed. Correct heat treatment of soybeans increases the biological efficiency of the protein for some classes of livestock.

The beans can be fed whole to sheep and hogs. It is better to crack or grind them, however. Practical experience shows it is advisable first to mix the beans with corn, oats, or peas and then grind them together into meal; soybeans are difficult to grind alone because of their high fat content. Owing to the high protein content, soybeans should always be fed in mixtures with a less concentrated feed. The composition and the amount of digestible nutrients of soybeans, in comparison with other important legumes, are shown in table 4.

Feed for Swine

Extensive feeding tests show the soybean to be one of the cheapest sources of protein grown on the farm for balancing a ration of corn for fattening hogs. The oil in soybeans, under many conditions, tends to produce soft pork; hence, the beans have a limited use in fattening hogs. Soybean meal is better for this purpose.

Feeding trials show that hogs make more rapid and economical gains on a ration containing cooked or heat-treated soybeans than on a ration containing raw soybeans. Although cooking the whole bean makes it more palatable, it does not prevent the softening effect on the pork and, consequently, does not change the amount of soybeans that can be fed without lowering the quality of the carcass.

TABLE 4.—*Composition of the seed of soybeans and of other important legumes* [1]

Crop	Moisture	Protein	Fat	Fiber	Nitrogen-free extract	Ash	Digestible protein	Total digestible nutrients [2]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Soybean	9.8	36.9	17.2	4.5	26.3	5.3	32.8	86.2
Cowpea	11.4	23.6	1.5	4.1	55.9	3.5	19.4	76.5
Bean, field	11.8	22.9	1.4	3.5	56.1	4.3	19.9	75.6
Velvetbean	10.0	23.4	5.7	6.4	51.7	3.0	17.3	76.7
Horsebean	12.5	25.7	1.4	8.2	48.8	3.4	21.3	76.1
Jackbean	10.7	24.7	3.2	8.2	50.4	2.8	22.2	83.6
Peanut, with hulls	5.9	24.9	36.2	17.5	12.6	2.9	20.2	103.5
Peanut, without hulls	5.3	30.5	47.7	2.5	11.7	2.3	27.1	139.9
Pea, field	9.5	23.8	1.2	6.2	56.2	3.1	20.2	79.6

[1] Data obtained from MORRISON, F. B., FEEDS AND FEEDING. Ed. 20. 1050 pp., illus. Chicago. 1945.

[2] Energy relationship compared to digestible starch.

Feed for Dairy Cattle

The practice of feeding ground soybeans to dairy cattle was more common before soybean meal became generally available on the market. Feeding tests indicate that ground soybeans compare favorably with linseed meal in producing milk and maintaining butterfat percentage. Cracked soybeans alone give as good results in milk and butter production as a mixture of cracked soybeans, linseed meal, and cottonseed meal. Ground soybeans do not affect noticeably the consistency of butter until the grain ration contains 50 percent or more soybeans. Higher percentages may produce butter with a slightly gummy texture, though the flavor of the milk products is not affected.

Feed for Beef Cattle

Experimental feeding trials and practical experience indicate that the soybean is a valuable source of protein for breeding and fattening cattle. Good results in rate of gain and finish have been obtained from feeding whole soybeans as a supplement to a ration of shelled corn, corn silage, and clover hay for fattening steers. Gains have been similar for steers fed rations containing soybeans, cottonseed meal, or linseed meal as the supplement. Ground soybeans have been satisfactory as a protein supplement for maintaining breeding cows and suckling calves.

Feed for Horses

Very little use has been made of soybeans as a concentrate for horses and mules in the United States. Because soybeans are highly concentrated and farm horses do not require a high-protein concentrate, any increase in the use of the beans as horse feed seems doubtful.

In the Orient, especially in Japan, soybeans rather than oats are used as feed for horses. They are the only grain fed; hay from wild grasses and legumes is given in addition to the soybeans. The yellow-seeded varieties are generally used, although in China black-seeded varieties are considered superior to yellow-seeded varieties for horses. In Japan, the beans are soaked overnight in water and then fed at the rate of 4 to 5 pounds a day for each horse. For working horses, 30 percent more of the soaked beans are added. On horse-breeding farms, each stallion is fed 6 to 7 pounds of soaked beans a day.

Feed for Sheep

Whole or ground soybeans, fed in not too large a quantity, are a good supplement for fattening or growing lambs. Feeding experiments at State agricultural experiment stations show little difference in value between whole soybeans and ground beans for sheep. They are more palatable when fed whole, but, if ground, they should be mixed with other grains.

Feeding tests indicate that ground soybeans can replace soybean meal, cottonseed meal, or linseed meal as the protein concentrate in a ration for fattening lambs. Ground soybeans give more economical gains than whole soybeans for lambs.

Tests by the Bureau of Animal Industry, at the Agricultural Research Center, Beltsville, Md., indicate that feeding soybeans to lambs causes no softness in the fat. In a feeding experiment, one experimental lot of lambs received the usual quantity of cracked corn, cottonseed meal, and alfalfa hay; the second lot, only cracked soybeans and alfalfa hay; and the third lot, equal parts of cracked soybeans and cracked corn with alfalfa hay. The average gain of lambs in each lot was more than a third of a pound a day while on feed. The lambs on the corn-soybean-alfalfa ration ate more readily than those on soybeans and alfalfa. It was concluded that, if both corn and soybeans are available, the combination probably is better than soybeans alone, although there was little difference in the carcass quality of the lambs from the three lots.

Poultry Feed

Extensive feeding tests show that soybeans are a valuable high protein feed and may be used to good advantage in poultry rations. When used for poultry, however, the soybean ration must be supplemented with a mineral mixture. Practical experience indicates that after soaking and cooking, the whole beans are more readily eaten by poultry. At present ground soybeans are not so generally used for poultry as soybean meal because the meal has a higher nutritional value. Mashes containing ground soybeans as the only supplement have not given so good results as those containing soybean meal as the only protein supplement.

Feed for Wild Game

Farmers and sportsmen have observed that quail like soybeans. Given the opportunity in the wild, these game birds will eat large quantities—eight birds were reported as making 74 percent of their last meal from soybeans and four birds as feeding on soybeans exclu-

sively. Soybean fields in areas where they have been planted for the first time may not be frequented by quail until the second, or even the third season, but then they may be occupied by several coveys almost simultaneously.

Much is yet to be learned of the relative merits of the numerous varieties of soybeans for quail feed. The seed of such varieties as Laredo and Otootan, which are small and remain sound in the field during the greater part of the winter, are well accepted by doves and quail. The Wilson variety, a black-seeded type, also is said to be well accepted. Soybeans hold an important place in the diet of quail propagated in captivity.

Pigeons are very fond of soybeans. When numerous, they have greatly injured soybean plantings by picking off and eating the cotyledons (seed leaves) just as the seedlings were emerging or by picking out the planted seed from the rows.

SOYBEAN STRAW

Soybean straw, left after threshing the beans from the plants, until recently was generally used for feeding. Since the advent of the combine, soybean straw has been used more extensively for spreading on the land for its fertilizing value and effect in lessening soil erosion. By removing only the seed and leaving the leaves, stems, roots, and pods on the land, more than half of the nitrogen contained in the soybean plant is returned to the soil and erosion is markedly decreased. It is especially important, if no fall-sown cover crop follows soybeans, to return the soybean straw and scatter it evenly over the land as a protection against winter erosion.

Feeding Value of Straw

Soybean straw from mature plants harvested for seed is low in protein and high in fiber; cattle refuse to eat about 40 percent of the straw offered to them. Although relatively poor as a roughage for high-producing dairy cows, soybean straw does have value for wintering dry cows and heifers, provided the animals are fed liberally and are not forced to eat the coarse portions and provided also that the straw is supplemented with a good legume hay. Soybean straw has been found a most satisfactory roughage for wintering idle work horses and mules. It may be fed to sheep, but it has relatively little value, the more palatable and nutritious parts—the seeds and leaves—having been removed.

Feeding trials show soybean straw to have less than a third of the value of soybean hay for breeding ewes. In composition, it compares favorably with other legume straws and the cereal straws.

Fertilizing Value of Straw

A few experiment stations made some studies of the plant nutrients contained in soybean straw and the protection it can give against erosion if returned to the soil when the crop is harvested for beans. The Illinois Agricultural Experiment Station found, on the basis of an assumed 20-bushel-per-acre crop of soybeans, that approximately 19 pounds of nitrogen is contained in the straw. The Iowa Agricultural Experiment Station found that the straw in a 43-bushel-per-acre crop contained about 33 pounds of nitrogen. This indicates the loss, espe-

cially of nitrogen and organic matter, when soybean straw is burned or not returned to the soil.

Studies by the Soil Conservation Service on the effect of crop and surface mulches on runoff and soil losses on a 4-percent slope showed that loss for October where the soybean residue was returned to the soil was only 11 percent as great as where the residue was not returned. The residue was still active the next April in preventing soil washing; the soil loss was 23 percent of the loss without the residue.

SOYBEANS PROCESSED FOR MEAL AND OIL

Soybean oil is highly important in both the domestic and the international vegetable-oil supply and economy (fig. 3). In Manchuria the soybean is grown largely for oil and meal; the Manchurian farmer relies on it as a cash crop. It constitutes a staple product of Manchurian agriculture and occupies about 25 percent of the total cultivated land. Before the Russo-Japanese war, China and Japan were not only the greatest producers but also the greatest consumers of the soybean and its products. About 1908 the first successful importations of soybeans from Manchuria were received in Europe. The beans were utilized by extracting the oil, which was found valuable for various industrial purposes, and for feeding the meal to livestock.

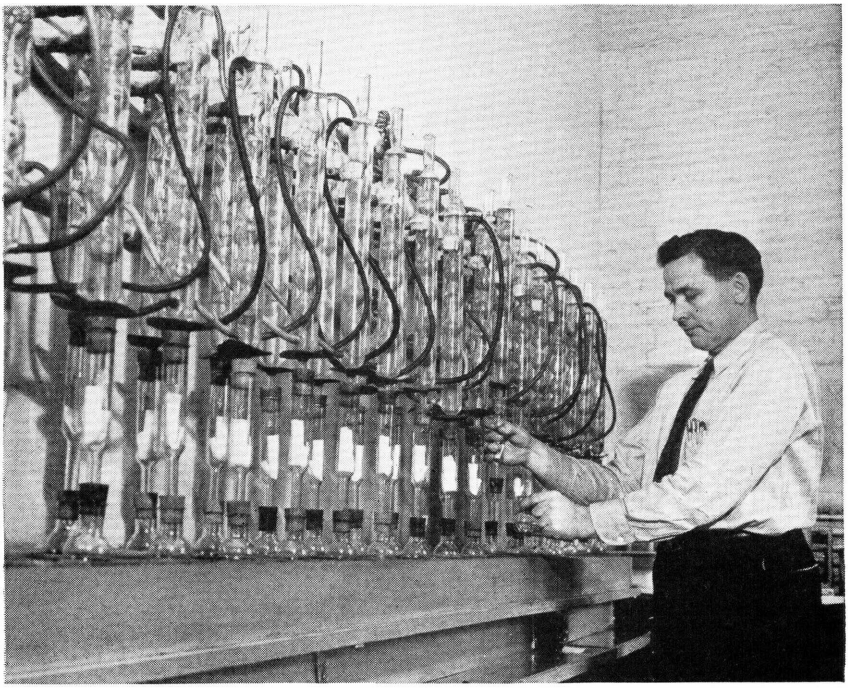


FIGURE 3.—A battery of oil extractors in a laboratory. Thousands of selections from soybean varieties and their crosses are analyzed for oil content. From these chemical determinations it is possible to recommend to the farmer the best varieties and strains to grow for oil-processing plants.

965338°—52——3

As the value of the oil and meal became recognized, new uses and markets were found and trade in the soybean and its products became very important. The soybean now competes with other oilseeds on the European market.

Soybeans were first processed for oil in the United States about 1910, when an oil mill on the Pacific coast used beans imported from Manchuria. Although many efforts had been made to interest cottonseed-oil mills in the South in processing domestic-grown soybeans for oil and meal, no extensive work was done until the latter part of 1915. A shortage of cottonseed in the South and a surplus of soybeans in North Carolina led several cottonseed oil mills in that State to begin production of soybean oil and meal. Exports to Europe and increased interest in the use of the soybean as a livestock feed and human food brought about a large demand for seed, with, in consequence, high prices, which made the crushing of domestic soybeans unprofitable. A screw-press mill at Chicago Heights, Ill., processed a small quantity of soybeans in 1917–18 and intermittently during the next few years. Soybean processing may be said to have become established as an industry in the United States in the early 1920's; it continued, but on a small scale, until about 1930. It was not until 1935–36 that as much as half of the domestic production of soybeans was so used. The volume of processing has increased rapidly since 1936.

By 1944 there were 137 soybean-processing mills, including those under construction. Their total capacity was estimated at 172 million bushels a year. In addition, soybeans were processed on a temporary or part-time basis by mills crushing other oilseeds. The total number of mills has not increased appreciably since then, but the crushing capacity has increased substantially. In 1950 the total capacity of soybean processing mills in the United States (fig. 4) was estimated to be more than 225 million bushels.

FIGURE 4.—One of approximately 140 mills, with a total capacity of over 225 million bushels, that are now processing soybeans for oil and meal.

Soybean meal, the residue after the beans are processed for oil, is a most valuable product, with a wide range of uses (fig. 5). It is a highly concentrated and nutritious feed, extensively fed to all kinds of livestock, poultry, and fur-bearing animals in North America and Europe. In the Orient the principal use of the meal is for fertilizing—rice and truck crops—and also for feeding work animals (fig. 6). Meal as a flour for human food has become increasingly important in Europe, North America, and the Orient. The industrial utilization of soybean meal is still in the early stage of development. When the meal is used for food or industrial purposes, certain changes are usually made in the processing methods to obtain a product with the desired characteristics for each special use (fig. 7).

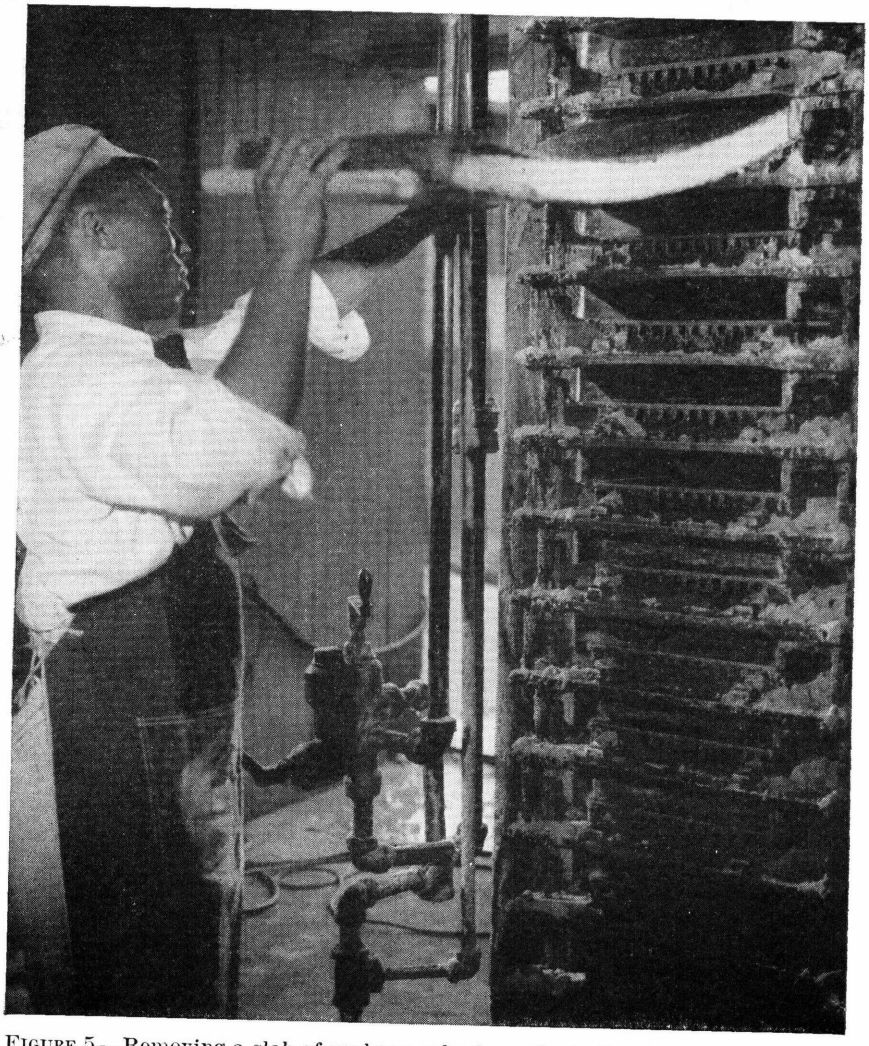


FIGURE 5.—Removing a slab of soybean cake from the hydraulic press, which has extracted the oil from it. This makes a highly concentrated and nutritious meal for livestock.

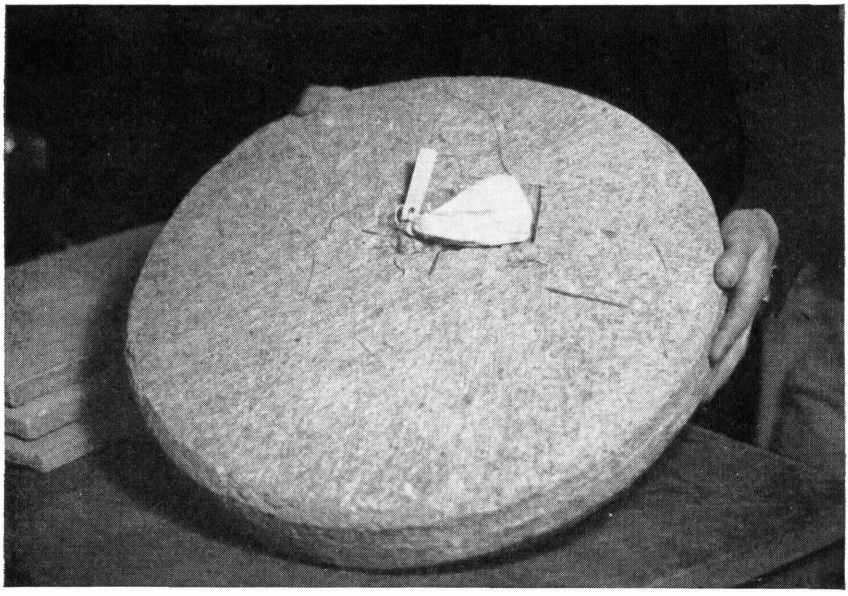


FIGURE 6.—Cart wheel of soybean cake made by pressing the oil from soybeans. This product is widely used in the Orient as a feed for livestock.

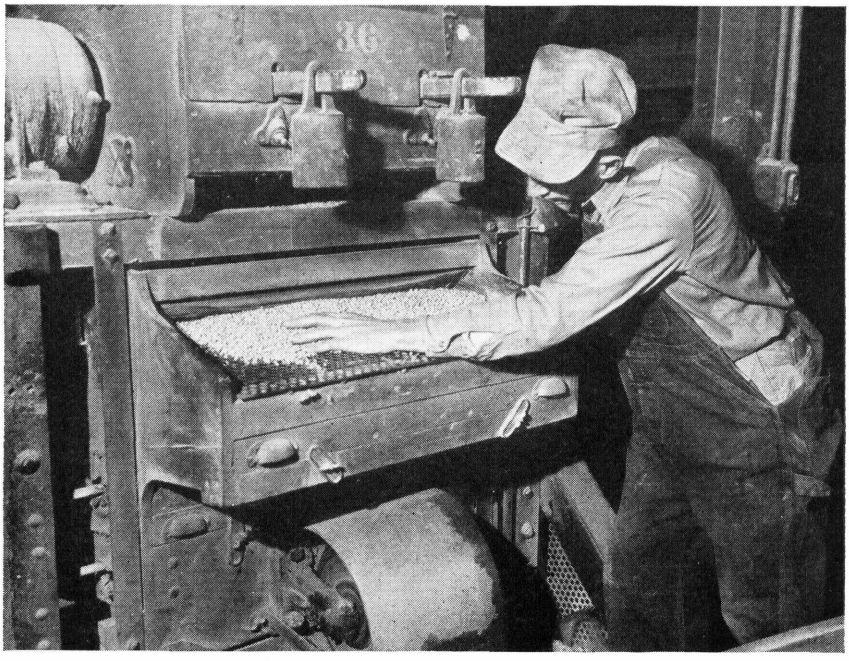


FIGURE 7.—Cleaning soybeans, carefully selected for conversion into food for human consumption, before they are fed into the corrugated rolls that crack them into small particles.

PROCESSING METHODS

Three methods are commonly used in processing soybeans for oil and meal—hydraulic pressing, expeller or continuous pressing (screw presses), and solvent extraction. Hydraulic pressing, the least economical method, is limited in the United States almost entirely to mills that are or have been engaged primarily in processing cottonseed or linseed. In 1940–41 screw presses handled about 74 percent of the beans processed (fig. 8), and solvent extraction about 23 percent. There has been a rapid expansion of both screw-press and solvent-

FIGURE 8.—Soybean oil, freshly expelled from screw presses, is pumped from storage tanks through a filter press to remove particles of meal suspended in it. This oil will be further refined for use as salad oil, shortening, or margarine.

extraction plants since the middle 1930's. The expansion of the solvent-extraction type in recent years has been the greater of the two; it is estimated that at least 75 percent of the soybeans grown in 1951 to be crushed will be processed in solvent-extraction plants. In the Orient soybeans have been processed almost entirely by hydraulic presses or similar equipment. Shortly prior to World War II, however, large oil mills with modern machinery were erected in Japan and Manchuria. Soybeans have been processed almost exclusively by solvent extraction in Europe.

The yield from a bushel (60 pounds) of soybeans processed by screw presses is about 9 pounds of oil and 48 pounds of meal. The meal contains from 40 to 45 percent protein and 4.0 to 5.5 percent oil. The average yield from a bushel of soybeans processed by solvent extrac-

tion is about 10.5 pounds of oil and 45 pounds of meal. Solvent-extracted meal contains 43 to 48 percent protein and 1.0 percent or less oil. Deviations from these figures may occur because of variation among varieties, effect of environment, and efficiency of operation of individual mills.

MEAL FOR LIVESTOCK

The principal use of soybean meal in the United States is as a livestock feed (fig. 9). It is estimated that 90 to 98 percent of the total domestic disappearance has been for this use. Practical experience, supplemented by extensive feeding experiments in the United States and in several European countries, indicates the high feeding value of soybean meal for all kinds of livestock. Research has shown the need for maintaining in mixed feeds a much higher protein level than was formerly thought necessary. These findings have resulted in a marked trend toward greater consumption of protein supplements.

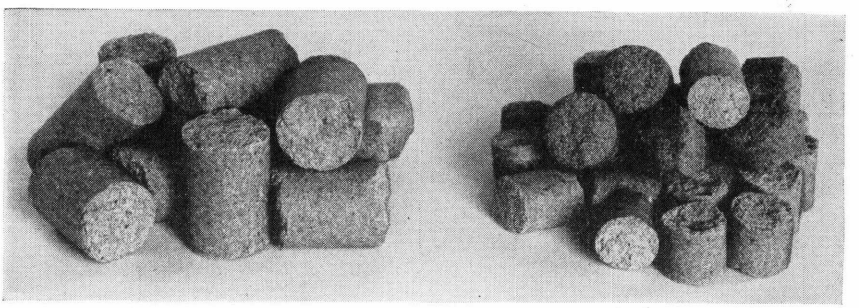


FIGURE 9.—Soybean-meal pellets for cattle (left) and sheep (right). (Slightly smaller than actual size.)

Alleged injurious effects from feeding soybean meal have been reported in the United States and Europe, but careful investigation has given no proof to substantiate these allegations. To avoid digestive troubles that may result from the high protein content, the meal should be fed with the precautions observed with other highly concentrated feeds.

Soybean meal has been known primarily as a protein concentrate, but recent investigations show that it also has a definite place among vitamin supplements. It is a significant source of vitamin B_1, equal to or better than such grains as corn and wheat. To date, soybean meal finds its highest practical value in its content of vitamin B_2 (riboflavin) complex. Vitamins A, E, F, and K are too low in soybean meal to be important in regular dietary practice.

In total digestible nutrients, soybean meal compares favorably with other meals (table 5).

TABLE 5.—*Composition and digestible nutrients of soybean meal and other important feeds* [1]

Oil meal	Moisture	Protein	Fat	Fiber	Nitrogen-free extract	Ash	Digestible protein	Total digestible nutrients
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Soybean, hydraulic- or expeller-pressed	8. 3	44. 3	5. 7	5. 6	30. 3	5. 7	37. 7	82. 2
Soybean, solvent-extracted	8. 4	46. 4	1. 6	5. 9	31. 7	6. 0	39. 4	77. 6
Cottonseed, 45 percent protein or more	7. 0	45. 6	7. 8	8. 9	25. 1	5. 6	37. 8	80. 8
Linseed meal, old process	8. 7	35. 2	6. 3	8. 0	36. 3	5. 5	30. 6	78. 2
Linseed meal, solvent-extracted	9. 6	36. 9	2. 9	8. 7	36. 3	5. 6	31. 0	72. 3
Peanut, old process, 45 percent protein or more	6. 0	46. 4	8. 6	9. 2	24. 3	5. 5	41. 3	83. 5
Peanut, solvent-extracted	8. 4	51. 5	1. 4	5. 7	27. 2	5. 8	45. 8	73. 8
Sunflower	10. 0	34. 8	18. 3	10. 9	21. 8	4. 2	32. 0	87. 4
Wheat middlings	10. 0	17. 4	5. 5	6. 8	56. 1	4. 2	14. 4	78. 4
Wheat bran	9. 4	15. 8	5. 0	9. 5	54. 3	6. 0	13. 1	70. 2

[1] Data obtained from MORRISON, F. B., FEEDS AND FEEDING. Ed. 20. 1050 pp., illus. Chicago. 1945.

Meal for Dairy Cattle

Extensive feeding trials in the United States and several European countries proved soybean meal to be an excellent protein supplement to a low-protein ration for milk production, giving results equal to and in some cases superior to those obtained with cottonseed, linseed, and other meals.

Comparisons of screw-pressed and solvent-extracted soybean meals show no difference in digestibility and feeding value for dairy cows. When fed in mixtures with other grains no marked difference is shown. Given a free choice as a straight supplement, however, cows, in some instances, have preferred screw-pressed meals.

Meal for Beef Cattle

Feeding trials at State agricultural experiment stations have shown soybean meal to be as efficient as cottonseed meal and linseed meal in producing gains on steers. Screw-pressed and solvent-extracted soybean meals are equally nutritious as a supplement to a fattening ration for cattle.

Soybean meal is preferred to whole or ground soybeans as a supplement for steers because it is less likely to have an undue laxative effect. Also steers on long feeding periods tend to tire of soybeans, probably because of the high oil content.

Meal for Poultry

With the rapid expansion of soybean processing, soybean meal has become quantitatively the most important protein supplement for poultry. Previously it was common practice to supply about half the total protein of poultry mash feeds in the form of animal-protein supplements. At present, to a large extent the animal-protein supplements taken out of poultry feeds have been replaced with soybean meal. The addition of a mineral mixture increases the value of soybean meal as a protein supplement for growth and egg production.

The preparation of soybean meal for poultry feed must be carefully controlled for maximum efficiency of the ration. Screw-pressed meals are sometimes overcooked; hence, solvent-extracted meals may be preferable in poultry rations, especially in chick starters, because in this extraction method temperatures may be held lower and the cooking process controlled more carefully. The quantity of fiber normally present in soybean meal is not necessary in starter or broiler rations, and some advantage is obtained from feeding meal from which most of the seed coats have been removed, giving a meal that is higher in protein and lower in fiber. Very efficient rations may be prepared for poultry by using soybean meal as the principal source of protein and including some protein of animal or marine origin, together with certain vitamins.

Feeding trials show soybean meal to be superior to ground soybeans as a protein supplement for poultry. Proper cooking, which improves the digestibility of the protein, will increase the value of ground soybeans in the ration for poultry.

Meal for Swine

Soybean meal has proved to be an excellent protein supplement for swine of all classes. It is particularly well adapted to balancing rations of corn when hogs are on green pasture.

Solvent-extracted and screw-pressed soybean meals give similar results in producing gains if the meals have been properly heat-treated. The availability of some amino acids, especially methionine, is low in raw soybeans but is increased by the heat treatment during processing into soybean meal. The addition of certain vitamins, especially of the B complex, improves the efficiency of swine rations containing soybean meal as the main protein supplement; and certain mineral mixtures also improve their efficiency.

The fat in soybeans tends to produce soft pork and lard if the animals consume appreciable quantities of the whole or ground beans either raw or cooked. Soybean meal, either solvent-extracted or screw-pressed, is sufficiently low in oil content to permit feeding amounts adequate to balance a diet without unfavorably affecting the quality of the pork products.

Meal for Sheep

Extensive feeding tests and practical experience indicate that soybean meal is palatable to all classes of sheep, and that as a protein supplement it is equal to the other commonly used supplements in production of gains. Soybean meal has been found more palatable than ground soybeans for feeding lambs. When fed as a supplement to shelled corn and soybean straw, soybean meal resulted in more rapid gains and in the use of slightly less feed per hundred pounds of gain than linseed meal or cottonseed meal. In one test, lambs fed a 35-percent soybean-meal ration gained more rapidly than those fed other ratios of meal to grain, regardless of the ratio of grain to hay. The most rapid body gains and the most economical feed returns were obtained with lambs fed a 35-percent soybean-meal and grain ration, with a 3 to 2 ratio of grain to hay. It was concluded that soybean meal is an economical protein for growing lambs.

FIGURE 10.—Various forms of dog food made from soybean meal and soy flour.

Meal for Dogs

The rapid growth of the dog-food industry has resulted in equally rapid advances in the science of dog nutrition. The protein constituents are undoubtedly the most important part of the dog ration. Soybean meal and soy flour (fig. 10) are valuable and economical sources of a protein that exerts a supplementary effect on certain cereals. In addition to furnishing a high-quality protein when processed at controlled temperatures, soybean meal and soy flour have a higher mineral content than most cereals. The toasted flavor of soybean meal and soy flour seems to be particularly attractive to most dogs.

Meal for Rabbits

Studies to determine the value of plant protein supplements in rations for domestic rabbits indicate that considerable protein is required in their rations. Soybean meal, pea-size cake, and pelleted meal have proved desirable for adding the proper quantities of this protein-rich supplement to a basal ration of grain, legume hay, and green feed. The addition of soybean meal to a protein-deficient ration will increase the live weight of the young when weaned, and will make a substantial saving in feed costs. Soybean meal can be used in rations in the mash or in pelleted form. When used in a mash, the mixture should be dampened slightly before feeding, thus preventing separation or settling of the meal to the bottom of the feed trough, where it would be wasted.

Meal for Fur-Bearing Animals

Soybean meal has become an important ingredient in the rations for various fur-bearing animals. Excellent results have been obtained in feeding tests with foxes, in which a processed soybean product formed part of protein-rich materials in dry-type rations. Rations containing soybean meal, beef meals, and liver meal proved satisfactory for adult foxes and weaned pups. Foxes fed a ration with a total of 12 percent protein supplement from these sources were superior in growth, fur development, sheen, and absence of tinge to pelts to foxes fed rations containing 40 percent raw meat. There was little difference in the soybean meals, but pelts from pups receiving hydraulic- and screw-pressed meals were considered superior to those from pups fed the solvent-extracted meal.

Experiments have demonstrated that soybean meal can be satisfactorily substituted for part of the raw meat in a balanced ration for mink. Substantial quantities are being used for the purpose. Pelts from mink receiving the ration containing soybean meal were more desirable than those from mink receiving raw meat and liver, a large number of which were poorly furred and off-color. There was no significant difference between minks of the two groups in average live weight and general health. Soybean meal in this ration effected a substantial saving in feed costs.

Meal for Quail and Pheasants

In experiments at Patuxent Wildlife Research Refuge, Bowie, Md., quail chicks grew better on diets containing either soybean meal or peanut meal as the sole protein supplement than on diets containing linseed meal, cottonseed meal, or dried buttermilk as the main source of protein. The protein combination giving the heaviest weights, lowest mortality, and highest efficiency of feed utilization was 26 percent soybean meal and 14 percent sardine fish meal. The second best combination was a mixture containing 36 percent soybean meal and 9 percent menhaden fish meal. The first choice of the birds offered the various diets was the one containing 49 percent peanut meal; second choice was a mixture of 38 percent soybean meal and 9 percent meat and bone scraps; third choice was a mixture of 42 percent soybean meal and 16 percent dried buttermilk. Of 10 diets offered to

784 quail chicks in 1942, the one that seemed most promising from the standpoint of survival, bird weights, and efficiency of food utilization was 26.08 percent ground yellow corn, 10 percent ground millet, 7.5 percent dehydrated alfalfa-leaf meal, 50 percent solvent-extracted soybean meal, 3 percent dried whey, 1.5 percent special steamed bonemeal, 0.8 percent ground limestone, 1 percent salt mixture, and 0.12 percent D-activated animal sterol.

Soybean meal is a valuable food also for game birds other than quail. A ration containing 20 percent of soybean meal is excellent for starting ring-necked pheasants.

MEAL AS FERTILIZER

The use of soybean meal as a fertilizer has been confined almost entirely to Asiatic countries. The high fertilizing value of this product has long been recognized in the Orient. For centuries soybean meal has been used as a fertilizer on the sugar plantations of southern China, Indonesia (Netherlands East Indies), and other tropical islands. Large quantities of bean cake were imported annually from Manchuria by Japan and Korea for use in the rice fields and for mulberry trees. Throughout the Orient soybean meal is used extensively as a fertilizer on poor soils for both garden and field crops. Although large quantities of the meal have been imported and produced in the United States and Europe during the past 25 years (1926–50), little has been used as a fertilizer.

Like cottonseed meal, soybean meal is a good source of available phosphorus and potash, but its principal value as a fertilizer is as a source of nitrogen, which is highly available and is released at a rate favorable for plant development.

Soybean meal has been used to a limited extent for many years in fertilizers for lawns and golf courses as well as for flowers. Florists and rose and azalea growers have had excellent results with it. Test tobacco plots fertilized with soybean meal have given higher yields of higher grade tobacco than plots fertilized with cottonseed meal. Soybean meal has slightly more nitrogen to the ton than cottonseed meal and nearly twice as much potassium, which may account in part for its superiority as a fertilizer for tobacco.

MEAL FOR INDUSTRIAL PURPOSES

Although research chemists have been studying the value of soybean meal for industrial purposes for many years, the tonnage thus consumed is small in comparison with the quantity produced in the United States.

Much research has been done on the production of plastics from soybean meal, but the amount of meal thus consumed is negligible. The production of plastic of one type is based on the ability of the protein to react with formaldehyde to form a thermoplastic resin. Plastics of other types are produced by the simultaneous condensation of proteins and phenol (fig. 11), or of urea with formaldehyde in the presence of cellulose or carbohydrates. One process involves the mixture of soybean meal, phenol, formaldehyde, wood flour, ammonia, and lime that is screened and pressed into a mold at comparatively high temperatures. Wheat chaff, as well as wood flour, can be

used as a filler. Products made by this process include automobile horn buttons, gear-shift lever balls, switches, and distributor covers.

Glues made from soybean meal are used extensively in the plywood industry. Soybean glues give good mechanical bonds and are sufficiently water-resistant for uses where high humidity or outdoor weathering conditions are not encountered.

Another important industrial use for soybean meal is in the production of a purified protein fraction used in the paper-coating and allied industries. Paper sizings, adhesives, and various coatings are

FIGURE 11.—Plastic pieces molded from soybean phenolic molding powder.

made from it. During World War II large quantities were used as fire-fighting foam.

Soybean meal is used also in making artificial wool, foundry cores, water paint, emulsifier, and sprays.

MEAL IN FOOD PRODUCTS

The meal left after the oil has been taken from yellow-seeded soybeans is bright yellow when fresh and has a sweet, nutty flavor. The use of this meal in the form of flour, grits, and flakes for human food has become important in several European countries, in North America, and in the Orient. Less than 1 percent of the production of soybean meal was used in making soy flour in the years preceding World War II. During the war the manufacture of flour greatly increased, and the quantity produced in 1943 was equivalent to about 3 percent of the total soybean crop in the United States.

USE OF OIL

Soybean oil first attained commercial importance in the United States during World War I, when large quantities were imported from the Orient to replace fats and oils exported to Europe. Soybean oil has a combination of properties that qualify it as an ingredient for a wide variety of manufactured food and industrial products. It belongs to the group of semidrying oils and stands midway in its properties between linseed oil and cottonseed oil. Its drying qualities, color, odor, and taste vary with the source and variety of the bean, the care used in storage of both the beans and oil, and the oil-processing method.

From 1910 to 1950 the principal use of soybean oil at times was in soap, at other times in the drying (paint and varnish) industries, and more recently in food products. During World War I, most of the soybean oil imported went into soap, with some being used in the manufacture of shortening, margarine, paint, varnish, and explosives. In 1933–34 drying industries (paint and varnish) took up a larger percentage than either the food or soap industries. Beginning in 1935 there was a large increase in the proportion used for food, and since then the predominant use has been in edible products (table 6).

Oil in Food Products

Soybean oil, which has a low content of free fatty acid, a low refining loss, and a good flavor and color when carefully refined, is used in the manufacture of more than 50 products for human consumption in the United States. Great progress has been made in the past few years in methods of refining, bleaching, and otherwise improving the oil for food uses. The use of soybean oil for food was stimulated by supply and demand during World War II. In 1943, 79 percent of the domestic production was used for edible products. Since World War II the principal food use of soybean oil has been for shortening, margarine, and mayonnaise and salad dressing in that order. In 1948 soybean oil made up 54.3 percent of the total oils and fats used in shortening, 34.5 percent of the total in margarine, and 20.1 percent of the total in other edible products.

Industrial Use of Oil

Although 70 to 93 percent of the annual consumption of soybean oil in the United States has been in the food industries since 1935, there has been a rapid increase in its industrial use. The paint and varnish industry consumes the largest amount (fig. 12); with miscellaneous products—such as candles, cleaning compound, disinfectant, foundry oil, grease and lubricating compounds, rubber substitutes, patent and artificial leathers, waterproof fabric, glycerin, lecithin, medicinal oil, sticker for sprays, waterproofing cement, pharmaceuticals, cosmetics, food modifier, special emulsifier, petroleum products, and plastic compositions; followed by soap, linoleum, oilcloth, and printing ink.

TABLE 6.—*Utilization of soybean oil, by classes of products, in the United States, 1934–49* [1]

Year	Margarine	Shortening	Other [2]	Soap	Paint and varnish	Other drying-oil products [3]	Miscellaneous nonfood products	Loss, including oil in foots [4]	Total domestic disappearance
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
1934	24	2, 735	10, 284	1, 354	10, 451	4, 062	949	823	30, 682
1939	70, 822	201, 599	117, 297	11, 177	21, 720	11, 633	4, 199	16, 265	454, 712
1944	211, 105	620, 257	274, 856	3, 258	19, 105	17, 543	14, 295	69, 184	1, 229, 603
1949	257, 287	710, 642	242, 819	1, 991	106, 062	91, 725	36, 169	79, 797	1, 526, 492

[1] Compiled as follows: Utilization in margarine, from reports of the Commissioner of Internal Revenue; utilization in other products, factory consumption, from reports of the Bureau of the Census, except as noted.

[2] Includes an allowance for unreported disappearance, estimated by the Bureau of Agricultural Economics.

[3] Difference between total estimated use in drying-oil products and factory consumption in paint and varnish.

[4] Foots are used in nonfood products, largely in the manufacture of soap and fatty acids. Estimated since June 1942 as the difference between crude oil used in refining and production of refined oil.

FIGURE 12.—Soybean oil paint is tested for its possibilities as a traffic paint.

SOYBEANS AND PRODUCTS FOR HUMAN CONSUMPTION

Although the soybean has formed an indispensable part of the oriental diet for many centuries, the Western World has awakened only recently to its potentialities as a valuable and economical source of food in the human diet.

During the past few years remarkable progress has been made in developing food uses of the crop in the United States. The rapid increase in the production of soybeans caused an expanding interest in their nutritional value and possibilities as a food. Extensive investigations by industrial organizations, colleges, State agricultural experiment stations, and the United States Department of Agriculture have revealed the dietary value of the soybean and its products and have had much to do with the rapid and growing popularity of soybean food products.

Nutritional studies indicate that soybeans in both the green-vegetable and mature stages rank higher in food value than peas and beans, thus offering many possibilities in low-cost diets. Proteins, fats, minerals, and vitamins are the most costly constituents of our diet. The unusually high content and quality of the protein and fat of the soybean explain in part its high nutritive value. It is also a good source of important mineral elements, containing more calcium and phosphorus than any of the cereals and two to three times as much calcium as peas and beans, and is a good source of iron, potassium, and magnesium. At the different stages of growth and maturity, soy-

beans contain some of all the known vitamins. They are a good source of the vitamins of the B complex, particularly thiamine. Niacin and riboflavin are also present. Soybeans contain more thiamine than some vegetables and cereals but not so much niacin as wheat. They rate higher in riboflavin than cereals and most vegetables. Soybean sprouts contain vitamin C, which is not present in the dry bean. Soybeans are a good source of choline. Other vitamins present are pantothenic acid, pyridoxine, inositol, and biotin.

Soybean foods now receiving most attention are flour, flakes, grits, and oil. Soy flour, grits, and flakes are used extensively in the United States and in several European countries as a constituent in bakery goods, macaroni, noodles, soups, candies, ice-cream powders, prepared baking mixes, breakfast foods, and confections, and as an extender in meat products. Other foods on the market are baked soybeans, canned and quick-frozen green vegetable soybeans, soy butter, bean curd, special dietary foods, meatlike products, vegetable milk (liquid, fermented, and powdered), soy sauce, spreads, and infant foods.

VEGETABLE SOYBEANS

Varieties of soybeans grown in the United States may be divided into three general groups—commercial (grain), forage, and vegetable. The commercial varieties, preferably yellow-seeded, are used largely for processing for oil, meal, flour, grits, and flakes. In the Orient varieties have been developed for use as green vegetable beans, bean curd, bean sprouts, flour, and numerous other food products. More than 100 varieties used solely as green vegetable or dry edible beans in the Orient have been introduced; the term "vegetable varieties" is used to distinguish them from varieties grown for other purposes.

In extensive tests of the cooking quality and composition of the green and the dry soybeans by the United States Department of Agriculture and various agricultural experiment stations and colleges, the vegetable varieties have proved superior to the commercial varieties in flavor, texture, and ease of cooking. Nearly all vegetable varieties cook easily and have a sweet, bland, or nutty flavor. This group is superior to commercial and forage types for vegetable milk, soy flour, bean curd, and salted and roasted beans. The most suitable vegetable varieties are those with a straw-yellow, greenish-yellow, or green seed, although a few black-, brown-, and bicolored-seeded varieties do have superior qualities as green shelled beans.

For use as a green vegetable, the pods should be picked when still green and the seeds soft but fully developed. To shell green beans, the pods should be boiled or steamed for about 5 minutes, after which the beans are easily squeezed from the pod. Green soybean pods are tough and not desirable for food.

The shelled green beans may be prepared for the table in the same way as green peas or lima beans. They also may be canned, quick-frozen, or dehydrated in the same way as shelled peas and beans. Several commercial companies have canned and quick-frozen large packs of green vegetable varieties. Quick-frozen succotash, using the vegetable varieties, has become a popular food product (fig. 13). For canning and quick-freezing, the yellow- or green-seeded varieties are much more attractive than those having black, brown, or bicolored seed.

FIGURE 13.—A box of quick-frozen succotash, using vegetable varieties of soybeans with corn, has been placed on the market.

DRY SOYBEANS

The dry, or mature, soybeans of the yellow- or greenish-yellow-seeded varieties may be used in practically the same ways as other dry beans or peas in making many palatable and nutritious dishes. The vegetable varieties are more desirable for cooking than the commercial; they cook more quickly and have a better flavor. Some of the commercial varieties, however, may be used. Usually the dry beans from the most recent crop become more tender than do those kept for more than one season. A pressure cooker shortens the cooking time and produces a tender bean. Other uses of the dry soybean (principally of oriental origin) are in the preparation of soybean milk, soybean curd, soybean sprouts, beverages, and salted, roasted soybeans.

SOY FLOUR, GRITS, AND FLAKES

Improvement in processing has resulted in the manufacture of soy flours superior in flavor and keeping qualities to those first placed on the American market. In making flour from soybeans, the seed coat is first removed and the beans are debittered to eliminate the raw "bean" taste. Some of the methods of debittering, nearly all of which are patented, employ steam; a few use chemicals. Most of the processes involve heating with steam, which performs two important functions besides debittering—increasing the nutritive value of the protein and improving the keeping qualities of the flour. Flour from raw soybeans has a tendency to become rancid in a short time under hot, humid conditions.

The three general types of soy flour (fig. 14) now available are as follows (dry-weight basis): full-, or high-fat, with 20 percent fat and 40 percent protein; medium-fat, with 5 to 7 percent fat and 45 to 48 percent protein; and low-fat, with approximately 1 percent fat and 50 to 53 percent protein. These types have different water-absorbing capacities, the low-fat flour being the most absorbent. The nutritive value of soybean flour compared to a few other selected foods is given in table 7.

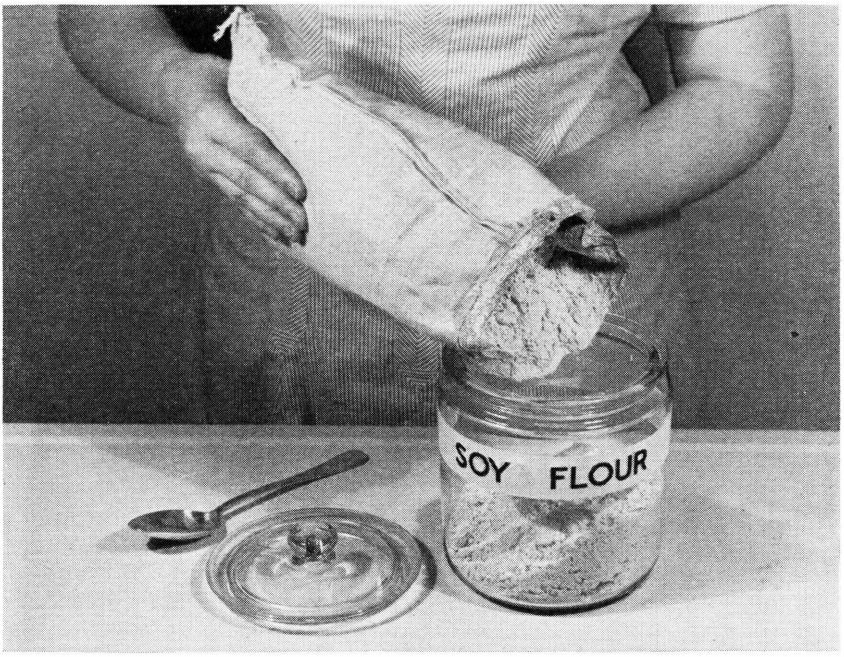


FIGURE 14.—Soy flour goes best in dishes containing finely ground flour, such as breads, cream soups, sandwich fillings, and scrambled egg-vegetable roll.

Soy flour differs from wheat flour in many ways. Lacking in gluten and low in starch, it cannot be used alone for bread or other baked products. Primarily a protein concentrate, soy flour is used principally to add to the nutritive value of other foods. For most purposes any one of the three kinds of soy flour may be added in small quantities to wheat-flour mixtures. Baked products made with low-fat soy flour tend to have a somewhat smaller volume and a little different texture from those made with the other flours. Lower baking temperatures may be necessary for soy products because soy flour browns quickly. Bakers have for some time been using a little soy flour in many products, because its property of holding moisture improves quality and adds to the shelf life of baked goods.

Soy flour, grits, and flakes can be used in many home-prepared foods, offering an economical method for adding essential food values to the daily diet (fig. 15). Soy flour in proper proportions with wheat

TABLE 7.—*Nutritive value of soybean flour compared to that of other selected foods, edible portion*[1]

(Determined in 100-gram samples)

Nutritive value	Soy flour, low-fat	Soy flour, full-fat	Beans, dry, seed	Peas, split	Yellow corn meal, whole grain	Rye meal, or whole grain	Wheat flour, whole wheat
Water—percent	11.0	9.0	11.5	10.0	12.0	11.0	12.0
Food energy—calories	228	347	338	344	355	321	333
Protein—grams	44.7	35.9	21.4	24.5	9.2	12.1	13.3
Fat—do	1.1	20.6	1.6	1.0	3.9	1.7	2.0
Carbohydrate—do	[2] 37.7	[2] 29.9	61.6	61.7	73.7	73.4	71.0
Calcium—milligrams	265	195	163	33	10	[3] 38	41
Phosphorus—do	623	553	437	268	256	376	372
Iron—do	13.0	12.1	6.9	5.1	2.4	3.7	3.3
Vitamin A—international units	70	140	0	370	510	[3] 0	[3] 0
Thiamine—milligrams	1.10	.77	.67	.77	.38	.43	.55
Riboflavin—do	.35	.28	.23	.28	.11	.22	.12
Niacin—do	2.9	2.2	2.2	3.1	2.0	1.6	4.3

[1] Values taken from WATT, B. K., and MERRILL, A. L., COMPOSITION OF FOODS—RAW, PROCESSED, PREPARED. U. S. Dept. Agr. Handb. 8, 147 pp. 1950. [Processed.]

[2] Approximately 40 percent of the total amount of carbohydrate calculated by difference is sugar, starch, and dextrin. The remaining portion is made up of materials thought to be utilized only poorly, if at all, by the body.

[3] Imputed value.

flour is ideal for breads, biscuits, muffins, corn breads, piecrusts, cakes, cookies, doughnuts, puddings, griddle cakes, and waffles. Soy flour and grits are excellent meat extenders and also may replace part of the protein in fish, egg, and cheese dishes.

Soy flour in varying percentages is being used in the manufacture of macaroni, noodles, and spaghetti. It is also used to some extent in meat loaves (fig. 16), canned meat products, sausage, frankfurters, and bologna. This flour has also found acceptable use in stews, soups, hash, and chili con carne. In the confectionery industry, 3 to 10 percent of soy flour is used as a constituent of many candies; the addition of soy flour aids emulsification of the fats used in the manufacture of candy and helps to prevent drying out of the finished product (fig.

FIGURE 15.—Soy grits are best in meat and fish dishes, in a vegetable casserole, with hot breakfast food, and in spoon bread and Indian pudding.

17). Specific nutritional characteristics of the soybean account for the wide variety of dietary foods developed wholly or in part from soy flour. The low starch content makes it an ideal constituent of foods where reduction of starch is a requirement. Soy flour has been used for many years as a constituent in manufactured dietary products and infant foods.

A proteinaceous whipping or gelling compound for use in specialty baked goods may be prepared from the water-soluble part of soybean flakes extracted or washed with ethyl alcohol. This bland-flavored whip may be used in ice-cream formulas, icings, and candies.

ORIENTAL SOYBEAN FOODS

Asiatic people have long appreciated the many uses of the soybean for food; for centuries the protein part of the diet of millions of them has been supplied or supplemented from the soybean. The soybean has meant bread, milk, meat, cheese, and vegetables to these people; it has furnished what is said to be a well-balanced diet at a relatively low cost. In most oriental countries dry soybeans are seldom used for boiling and baking, but in Manchuria and Korea they are boiled and eaten with millet, grain sorghum, and rice.

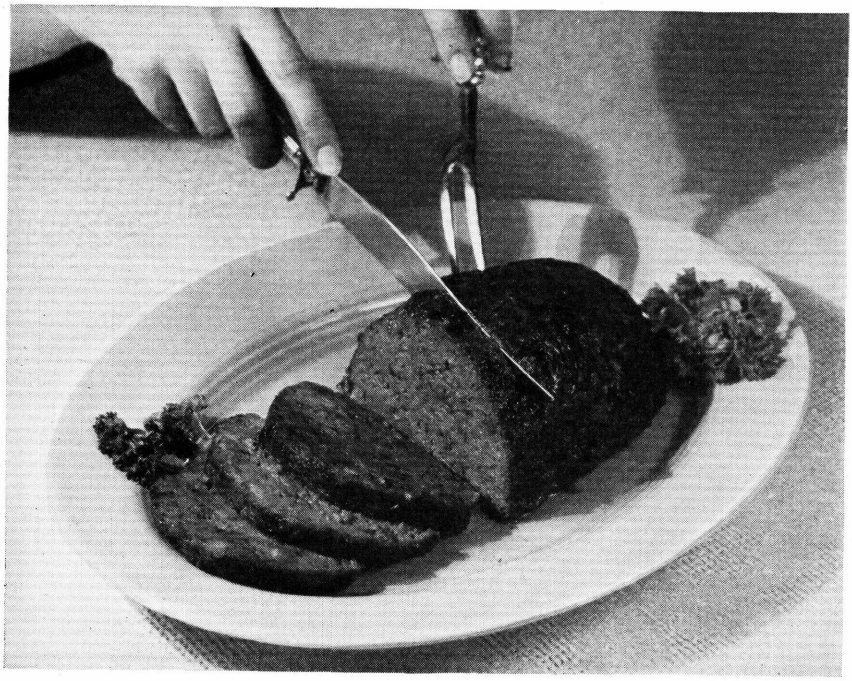


FIGURE 16.—Soy flour or grits in a meat loaf makes the meat go further, with no reduction in protein.

Fermented, the soybean yields various sauces and seasonings, which are useful as basic flavoring materials. Pressed, it gives oil for cooking. Sprouted, it furnishes a fresh green vegetable containing vitamins. Picked when immature, it makes an excellent shelled bean. Ground dry, it makes flour that is used in confections and health drinks. Soaked, ground, and mixed with water, it provides bean milk, and the curdled milk furnishes bean curd—the boneless meat of the Orient—used fresh and in the form of dried and fermented cheeses or as a meat substitute. The roasted beans—soaked in water and fried in oil or simply roasted—are used as salted beans and in cakes and candies. Fermented bean pastes (fig. 18, *A*) are used extensively in soups and in preserving vegetables, fish, and meat.

Fermented soybeans (fig. 18, *B*) are commonly eaten in China and Japan as a side dish. The roasted beans are also used as a cereal beverage and are often combined with herbs for health drinks.

SOY MILK

A liquid similar in appearance and properties to animal milk can be made from soybeans. It is not equal to cow's milk in food value, but it contains most of the same food elements in slightly smaller

FIGURE 17.—Sources of protein used to fortify candies include eggs and milk products, as well as soybeans.

amounts. Soy milk contains only the nutrients found in the dried beans—protein, fat, and B vitamins. It is lacking in calcium and vitamins A, C, and D, contains no lactose, and has a lower fat content than cow's milk. In extensive studies soy milk as a substitute for cow's milk has given best results only when its calcium, milk-sugar, fat, and vitamin contents were enriched. Soy milk varies relatively widely in composition with the composition of the beans used, fineness of grinding the soaked beans, ratio of water to mash, and temperature of extraction.

The preparation of soy milk varies widely. The whole bean or the full-fat flour can be used with about the same results. Soy milk is made in the Orient by soaking the dry soybeans (yellow- or light-greenish-yellow-seeded varieties preferably) for several hours, then

grinding them in a stone mill and adding more water—usually three times as much water as bean mash. The milklike product is strained through a cloth and heated to the boiling point for about 30 minutes. For the American home, three methods of preparing soy milk have been recommended.

Method 1. Wash soybeans thoroughly and soak overnight. Remove the skins by rubbing them off in the water; they will float to the surface and can be discarded. Grind the beans as fine as possible

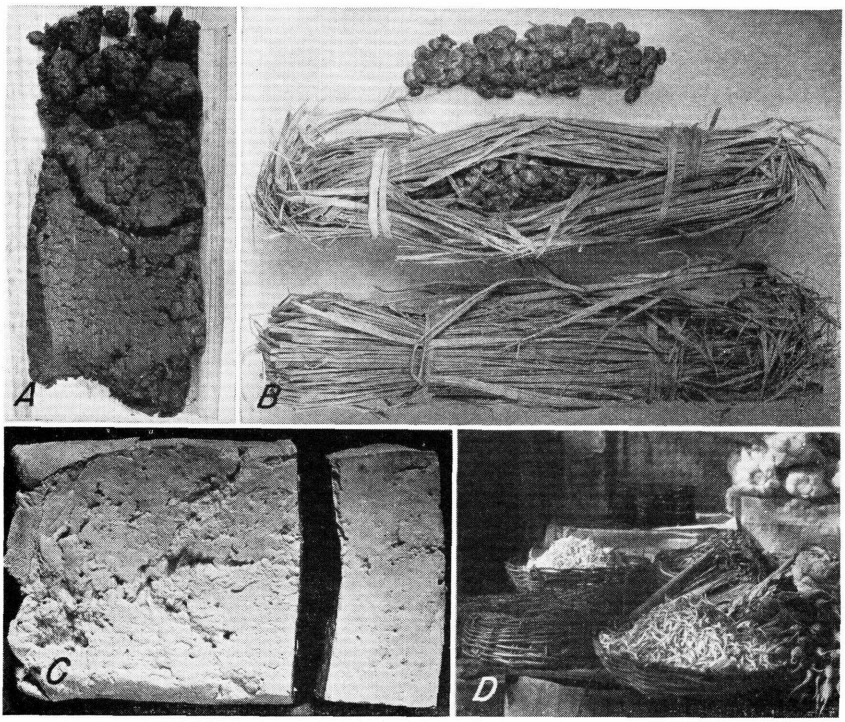


FIGURE 18.—*A*, Miso, or bean paste, used in making soups, cooking vegetables, and preserving various sea foods and vegetables; *B*, natto, or fermented soybeans, used commonly as a side dish and as a material for confections by the Japanese; *C*, blocks of freshly made bean curd, or tofu, which is a staple article of diet in Asia; and *D*, sprouts grown from soybean seed are used extensively by the Chinese as a green vegetable in a variety of dishes.

in a food grinder. Put the ground mash in a cheesecloth bag and immerse in a bowl or pan of lukewarm water, using 3 quarts of water to a pound of dry beans. Work thoroughly with the hands for 5 to 10 minutes; then wring the bag of mash until it is dry. Bring the liquid obtained to the boiling point and simmer for about 30 minutes, stirring frequently to prevent scorching. Add sugar and salt to taste. Keep in a cold place.

Method 2. Wash soybeans and dry thoroughly; crack by crushing coarsely in a food grinder. The skins can then be removed easily. Grind fine in the grinder. To each pound add 3 quarts of water and soak for 2 to 3 hours. Simmer this material for 20 to 30 minutes,

stirring constantly; then strain through a cheesecloth. Add sugar and salt to taste. Keep in a cool place. (Soy flour, soybean meal, and whole, ground soybeans may be utilized quite as well as the whole bean.)

Method 3. Add 5 heaping tablespoons of high-fat soy flour to 1½ quarts of water. Mix the flour and water thoroughly with an egg beater; then cook the mixture in the top of a double boiler for about 30 minutes. When the milk is to be used for a drink, add sugar and salt to taste. Keep in a cold place.

Many soybean varieties have been tested to determine those from which the best soy milk can be made. Soy milk from the Bansei variety was found to have the least "beany" flavor, but satisfactory milk was made from such other varieties as Hokkaido, Haberlandt, Mammoth Yellow, Woods Yellow, Rokusun, and Tokyo.

In the Orient, where dairy animals are few, soy milk is an important food for children and practically the only substitute for milk used both fresh and as the basis of vegetable cheeses. Soy milk can be used successfully in making custards, soups, breads, and cakes, in creaming vegetables, and in preparing cocoa or similar drinks. Seasoned with a little salt and sugar, it makes a good beverage. Soy milk has been prepared in the form of a dry powder, which is a dry mix or blend of either finely ground soy flour or the water-soluble materials of the seed plus calcium salt, sugar, and other nutrients. The dry milk powder also has considerable promise as an ingredient of pastry and bakery goods and as a component of prepared flours. Soy milk has been found of special value in diets for persons or infants allergic to animal milk. Just as cow's milk can be treated with a bacterial culture to make acidophilus milk, soy milk can also be treated to make acidophilus soy milk.

The ground soybean pulp or mash left after separating the liquid from the solid material is still of good nutritive quality, but it has very little flavor. It can be dried and made into flour for human food, combined with foods of more pronounced taste, or used for animal feed.

SOY CURD

A curd (fig. 18, *C*) can be made by adding magnesium or calcium salts, vinegar, rennet, or lactic acid to soy milk when hot or by allowing the milk to ferment naturally in a warm place. The addition of acid makes a firmer curd; fermentation gives it a texture much like that of cream cheese. This curd, after being drained and pressed, represents bean curd, or tofu, which is extensively eaten and forms the basis of numerous fermented, smoked, and dried cheeses in Asiatic countries. Soy curd, made fresh daily, is a staple article of diet among oriental peoples. Chinese and Japanese markets and restaurants in many cities of the United States sell fresh soy curd. Several firms in the United States can soy curd.

To prepare soy curd with vinegar, heat 2 quarts of soy milk to 180° F., add 1 cup of vinegar, and stir until well mixed. Let stand a few minutes while the curd forms. Put into a cheesecloth bag and dip the bag of curd in cold water several times to wash away the excess acid. Drain for about an hour and then press out the remaining liquid. Season with salt, pack tightly in a dampened mold, cover, and store in a cold place until firm enough to cut.

To prepare soy curd by the fermentation method, keep the soy milk in a warm place for several hours or until it forms a curd. Stir to break the curd, add an equal quantity of water heated to nearly boiling, and let stand for 10 minutes. Pour into a cheesecloth bag and drain for several hours. Press out the remaining liquid, season with salt, pack in a dampened mold, cover, and store in a cold place.

Soy curd is a highly nutritious food and no doubt it could be used by the American housewife for a variety of palatable, nutritious dishes.

Orientals use soy curd with cooked vegetables and in soups. Soy curd, especially the fermented type, has the consistency, appearance, and flavor of mild, soft cheese, and can be seasoned and used in the same manner. It may be added to omelet, welsh rabbit, creamed eggs, and many other dishes of that type.

SOY SAUCE

Soy, or shoyu, sauce, a dark-brown liquid with an aromatic odor and a peculiar salty taste, suggesting meat extract, is an indispensable seasoning in every oriental household. It is largely used in cooking as a relish or condiment, to increase the flavor and palatability of the diet, and as an aid in the assimilation of food. Soy sauce within recent years has gained in popularity in the United States.

Various methods are employed in the manufacture of soy sauce; consequently, many different grades are produced. The sauce is prepared from a mixture of cooked soybeans, roasted and pulverized wheat (sometimes mixed with barley, which gives a sweeter taste), salt, water, and a culture known as rice ferment produced by the fungus *Aspergillus oryzae*. In general, soy sauce manufacturers use nearly equal parts of soybeans, wheat, and salt, and about double the quantity of water. More salt is added in preparing the cheaper grades.

In the manufacture of soy sauce the soybeans are first boiled from 4 to 6 hours and then cooled for about 18 hours. The beans are then mixed with an equal quantity of wheat that has been browned and pulverized. Spores of the fungus *Aspergillus oryzae* are added, and the mixture is placed in shallow flats, which are held at a temperature of about 97° F. until the mass is slightly covered with the fungus. The salt is dissolved in boiling water and added to the molded mixture of beans and wheat. This mass is placed in large vats or jars and left to ferment from 6 months to a year, sometimes 2 to 3 years.

During the process of ripening, the mixture is stirred thoroughly twice daily in the summer, but in winter only once every 2 to 4 days. After ripening, the liquid is pressed out, boiled from 2 to 3 hours, and placed in tubs, small kegs, jugs, or bottles. The solid mass left after the liquid is pressed out contains a comparatively large proportion of protein and fat, which, after soaking in water to extract the salt, is used as a fertilizer and a cattle feed. In China the salted mash is used extensively to preserve and flavor certain vegetables, such as turnips and radishes.

Some factories in the Orient and the United States are employing a hydrolytic method for preparing soy sauce from soybean meal. The process is much shorter than the other methods.

SOY SPROUTS

Soybeans and several other species of beans, especially the mung bean, are sprouted and used as a green vegetable in the Far East. Soy sprouts (fig. 18, *D*) can be produced successfully in the home, and a year-round fresh vegetable that may be used raw or cooked can be obtained by sprouting soybeans in a flower pot, a glass fruit jar, or a strainer.

In producing sprouts, select a stock of clean, bright beans of the latest crop. Any of the field varieties may be used, but the yellow-seeded varieties have less conspicuous skins, though black-seeded varieties, such as the Cayuga, Peking, Wilson, and Otootan, seem to germinate more quickly and uniformly. Carefully hand-pick the seed, discarding everything except the clean, whole beans. Wash the beans thoroughly, cover with lukewarm water, and allow them to soak for a few hours (or at most overnight) until they are swollen. Place the beans in a container and cover them with dampened cheesecloth. Rustproof wire-mesh screening or cheesecloth can be used to cover the bottom of the container to allow for drainage. In using a glass fruit jar, cover the top with a piece of cheesecloth and tie it on securely. Invert the jar and place it in a dark spot at room temperature. Tilt it slightly so that excess water can drain away promptly. Pour plenty of water on the beans 3 to 4 times a day, thereby insuring thorough washing. The beans may be sprinkled each evening with chlorinated lime solution (1 teaspoon of calcium hypochlorite dissolved in 3 gallons of water) to keep down mold growth and spoilage. Chlorinated limewater is not needed to kill fungus growth if the seed is of good quality. In 3 to 4 days the sprouts will be 1 to 2 inches long and ready to use. Bean sprouts increase about six times their original volume. The commercial production of soy sprouts proceeds along the same lines, except that larger sprouting tanks or trays are used and the process is more carefully controlled.

Soybean sprouts can be used in many ways and are cooked and served with the bean attached. They are a fair source of thiamine, riboflavin, and ascorbic acid. The sprouts may be served raw in salads, cooked in various ways, and used in such dishes as omelets, stews, fricassees, and chop suey. They are very tender and lose their crispness if put into hot dishes more than a few minutes before serving.

A few companies have successfully canned soy sprouts. The New York (Cornell) Agricultural Experiment Station found that sprouts lend themselves admirably to quick-freezing.

SOY BEVERAGES

In the United States the first published use of the soybean other than for forage was as a coffee substitute. The Purdue Agricultural Experiment Station in 1892 reported that an Indiana farmer had been using roasted soybeans as a coffee substitute for about 8 years. Since then the soybean has been sold at various times as "coffee berry" and "coffee plant."

When properly roasted and prepared, the soybean makes an excellent beverage. In oriental countries, in the United States, and in

several European countries, the roasted soybean as a health beverage is a commercial product under various brand names. It has also been used extensively to blend with coffee.

MISCELLANEOUS USES OF THE SOYBEAN

HONEY PRODUCTION

The Soybean as a Honey Plant

Opinions on the value of the soybean as a source of honey for bees vary greatly throughout the soybean-producing areas. Bees visit soybean flowers extensively but, it is thought, mainly for the pollen. The soybean flower secretes only a small quantity of nectar. Bees in the North Central States seem to prefer sweetclover and other plants that bloom at the same time as the soybean. Nebraska beekeepers consider the soybean of slight value for the production of either nectar or pollen.

Soy Flour For Honey Bees

In early spring, beekeepers sometimes feed their bees soy flour as a pollen supplement and as a dry pollen substitute with good results. At the Minnesota Agricultural Experiment Station, feeding tests with four brands of soy flour as pollen substitutes for bees showed that the mortality of bees increased and their brood-rearing capacity decreased with the decrease of fat content and the protein efficiency of the food. Restoration of the fat content of 5.5 percent effected a decrease in mortality and an improvement in brood rearing.

SOY FLOUR AND GRITS IN DOG FOOD

Soy flour and grits are used largely in canned dog food and dog biscuits; but soybean meal is used more frequently in dry uncooked dog food. The general use and biological tests of soy flour and grits indicate they are a good digestible protein for dogs. It has also been found that the nonstarch carbohydrates from the soy products are rapidly digested and utilized by the dog.

SOY FLAKES IN BREWING BEER

Soy flakes made from fat-free soybean meal are being utilized in the brewing industry. The addition of soy flakes increases the protein of the beer and produces a better head of foam on the finished product. In brewing, the soy flour is an excellent food for the yeast and is employed partly for this reason.

SOY FLOUR FOR INSECTICIDES

Soy flour has been used to a limited extent as a sticker in fruit- and shade-tree sprays, primarily with stomach poisons, such as lead arsenate. More than 1 pound per 100 gallons of spray results in excessive runoff and inferior control; about ¼ pound per 100 gallons provides maximum deposit building and efficiency. Washing experiments indicate residues containing soy flour are easier to remove than otherwise similar residues with mineral oil.

U. S. GOVERNMENT PRINTING OFFICE: 1952